HVG-DGG
Service und Forschung für die Glasherstellung

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

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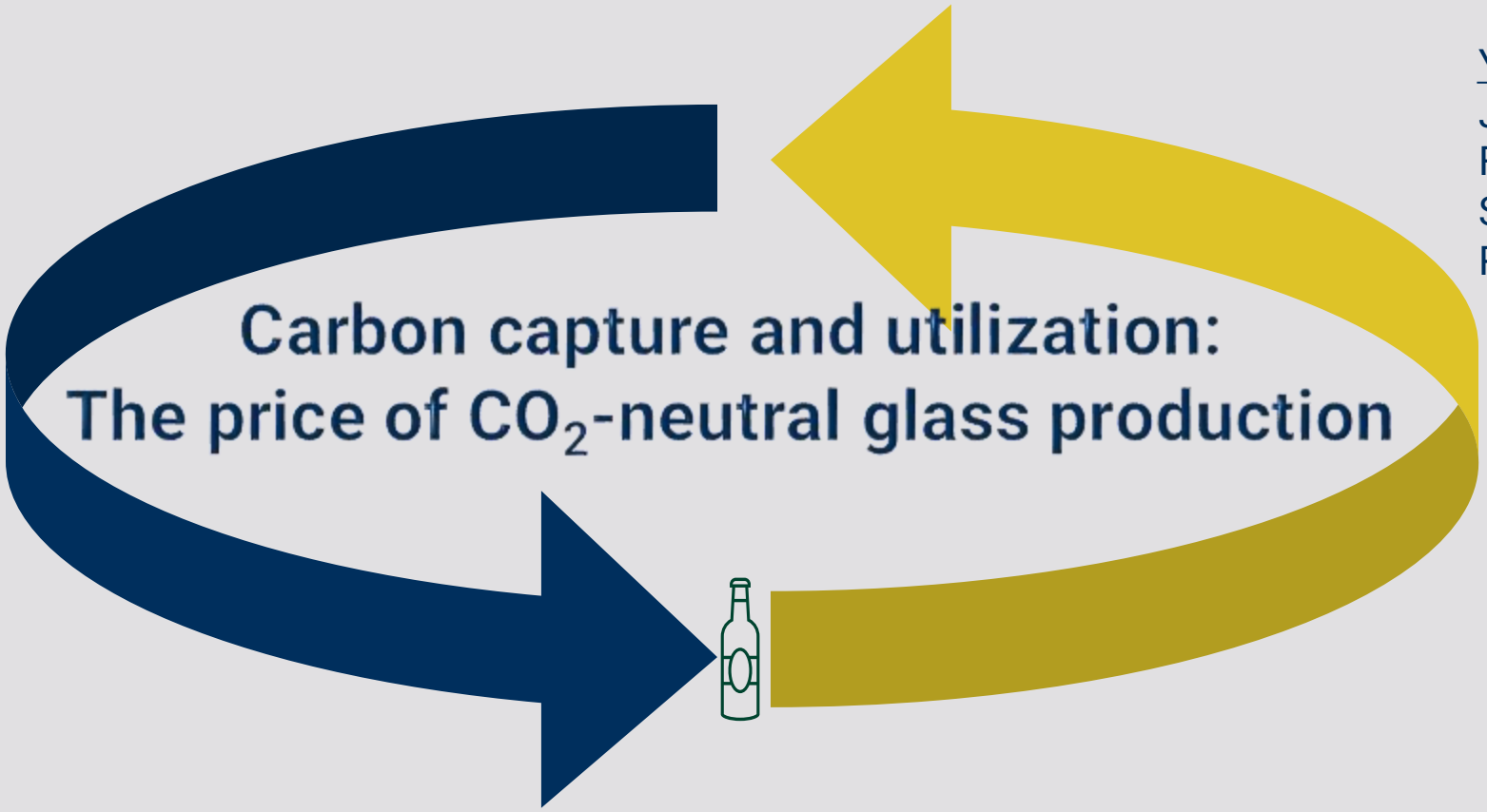
Carbon capture and utilization: The price of CO_2-neutral glass production



GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

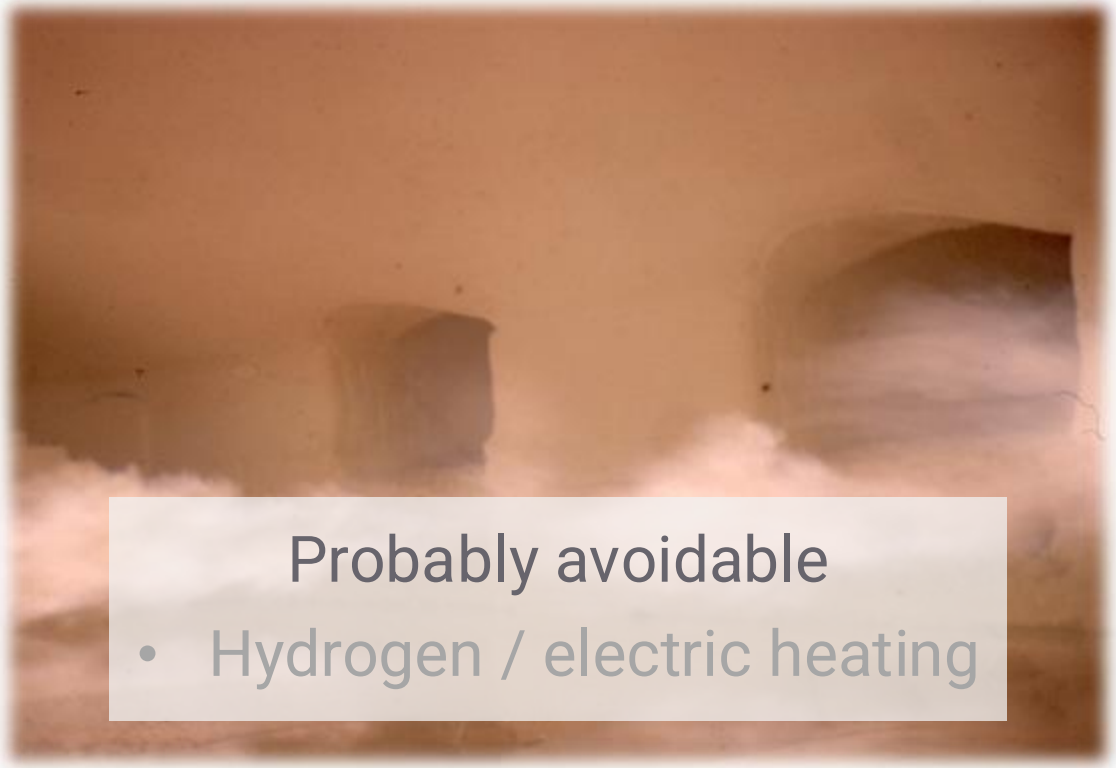
Finanziert von der Europäischen Union
NextGenerationEU

KlimPro BMBF 01LJ2005 (A+B)

ArdaghGlass
SCHOTT glass made of ideas
Linde Making our world more productive

PROJECT MOTIVATION
CO_2 sources in glass production

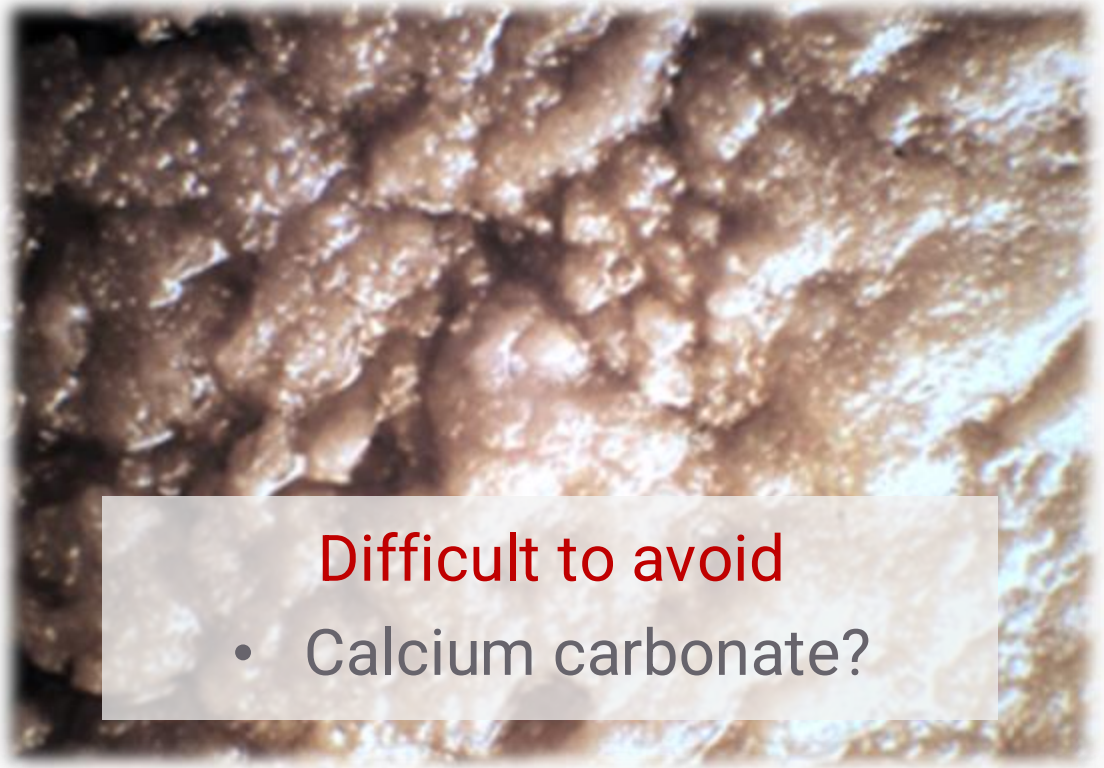
80%: Process Heat (CH_4)



Probably avoidable

- Hydrogen / electric heating

20%: Batch Decomposition (XCO_3)



Difficult to avoid

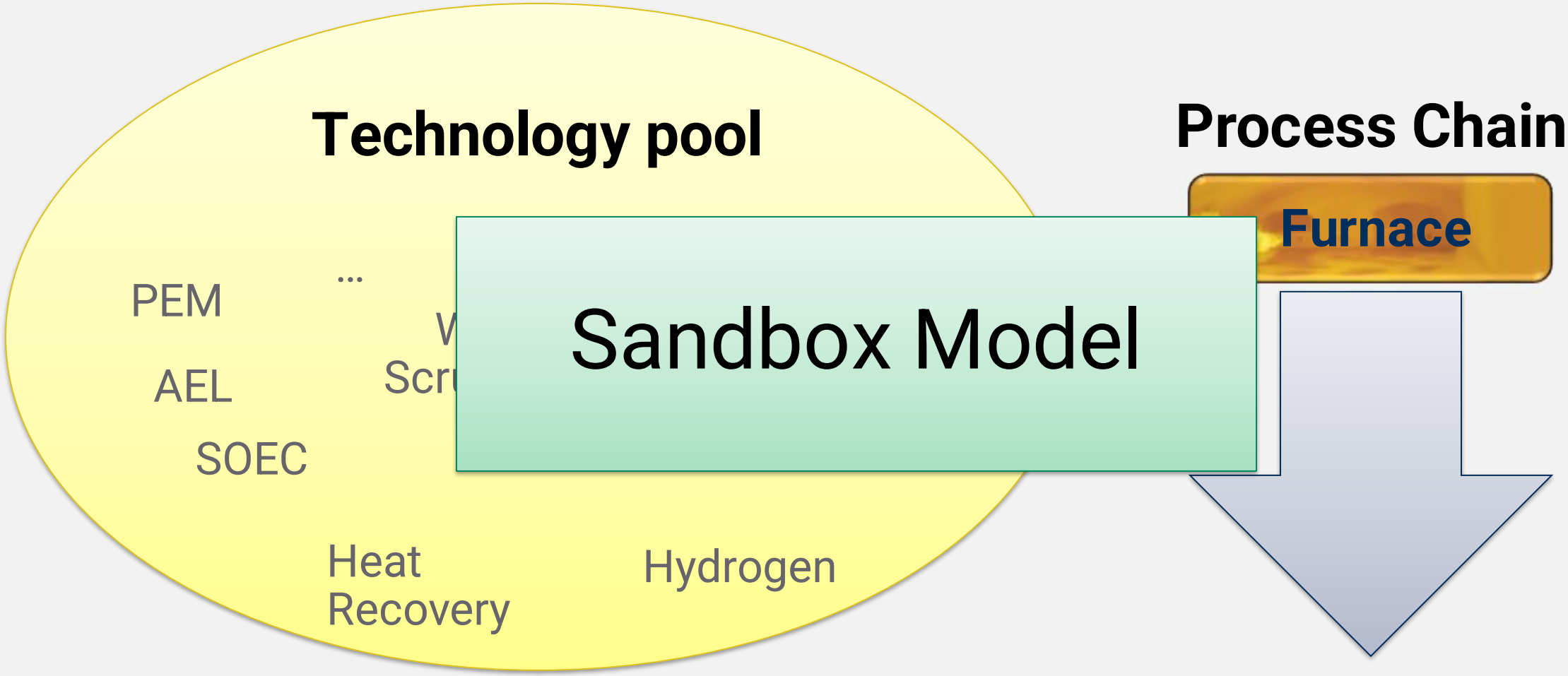
- Calcium carbonate?

MOTIVATION
Future CO_2 emissions

- CO_2 certificates will be as expensive as DAC+CCS
- DACCS state-of-the-art:

  ca. 1500 €/t_{CO2}

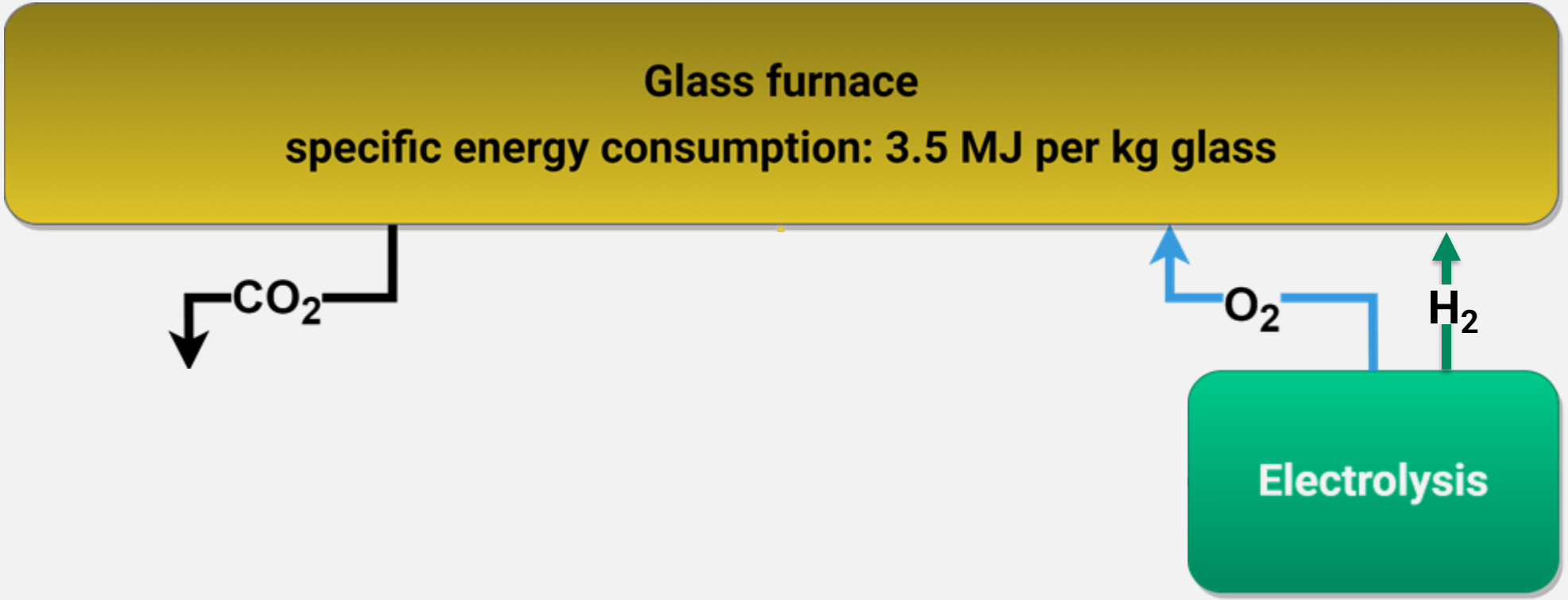
MOTIVATION
Basic idea



OUR PROCESS CHAINS

300 t glass / d	Ref.: H_2	a) H_2+MeOH	b) Me	c) MeOH
Intensive Gas cleaning	No	Yes	Yes	Yes
Heating	Hydrogen	Hydrogen	Methane	Methanol
Fossile surplus product	10 kt CO_2 / a	Methanol	Methane	Methanol

OUR PROCESS CHAINS



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EVALUTATION
Process chain efficiency

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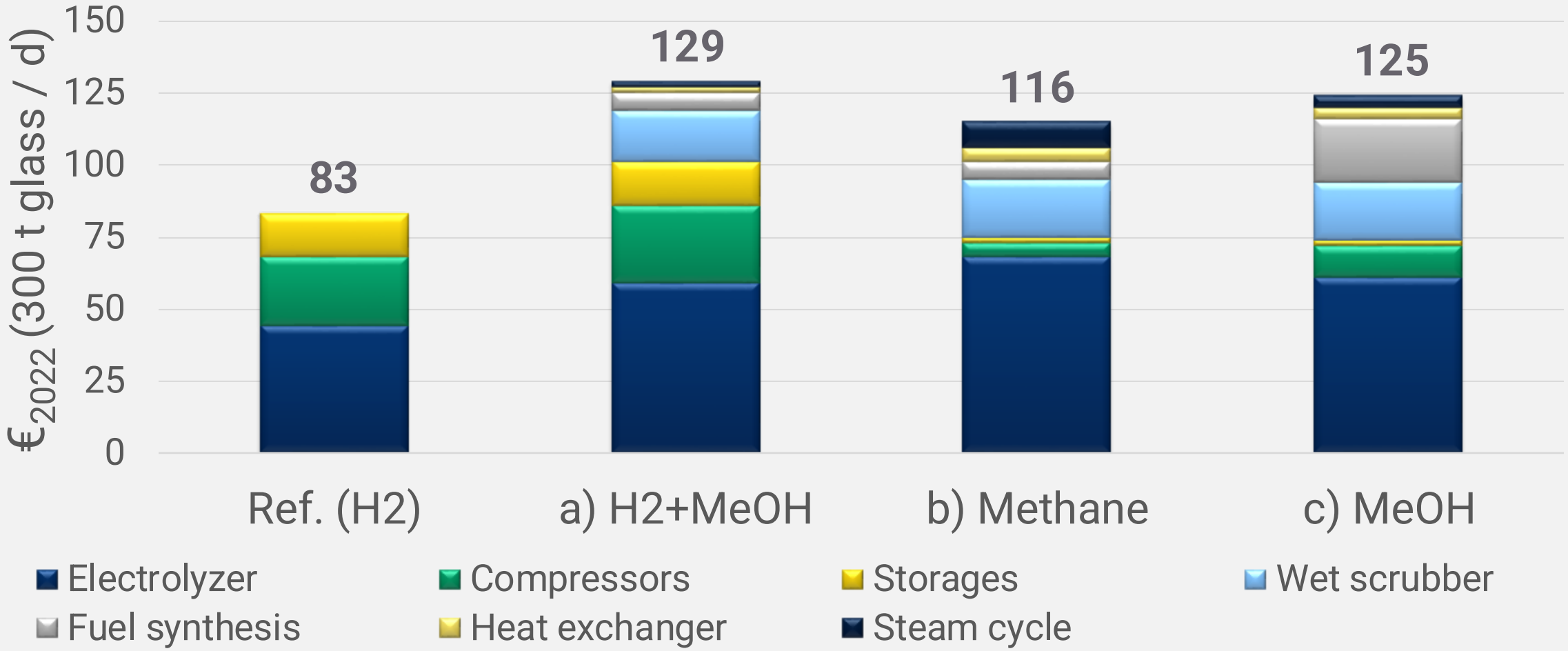
300 t glass / d	Ref.: H_2	a) H_2+MeOH	b) Me	c) MeOH
Intensive Gas cleaning	No	Yes	Yes	Yes
Heating	Hydrogen	Hydrogen	Methane	Methanol
Fossile surplus product	10 kt CO_2 / a	Methanol	Methane	Methanol
Electricity demand [MW_{el}]	27.5	36.8	46.4	39.6
Power-to-Fuel efficiency	44 %	42 %	38 %	37 %

TECHNO-ECON. ASSESSMENT
Calculation boundaries

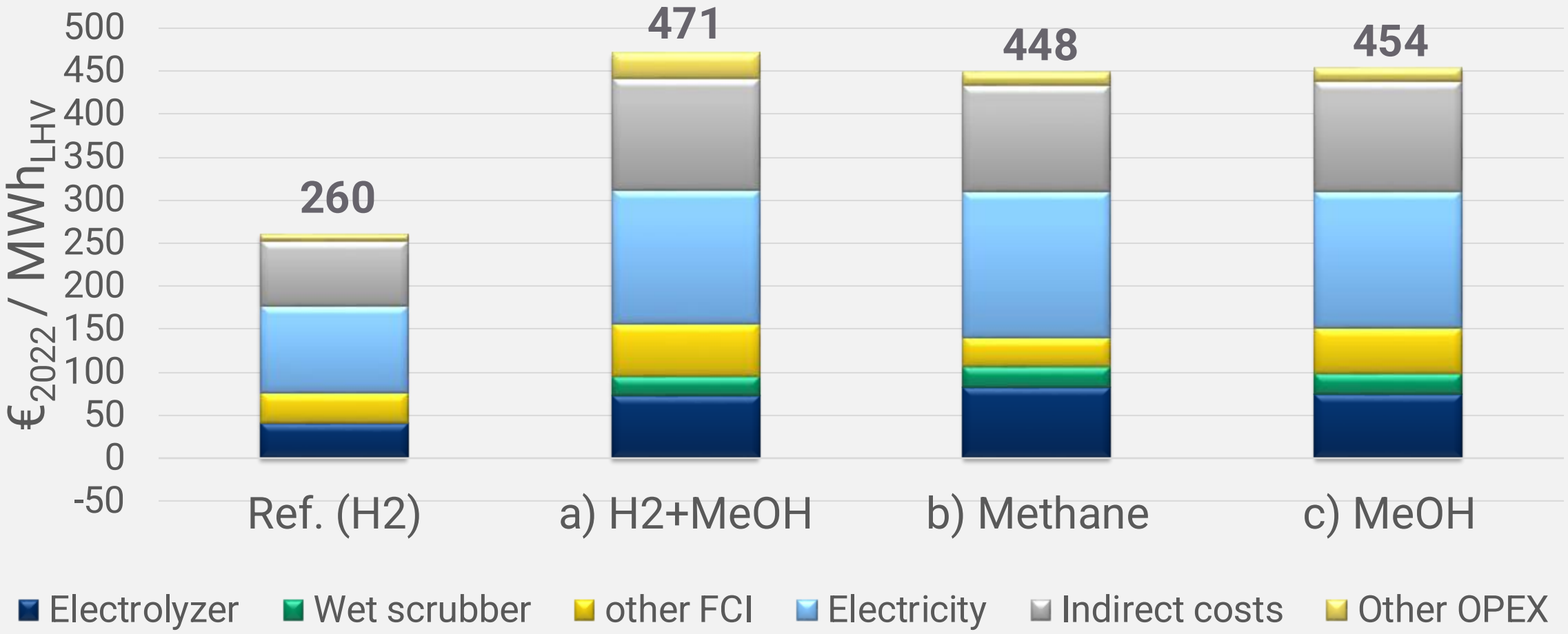
Evaluation input	
Plant capacity (lifetime: 15 a)	300 t_{glass}/day
Cullet rate	55%
Combustion	OxyFuel
Base year	2022
Interest rate (annuity CAPEX)	7%
Glass furnace operation	24/7/365
Methanation / electrolyzer plant full load hours	8000 h/a
Electricity price	60 €/MWh

EVALUATION
Techno-economic evaluation: FCI



EVALUATION

Techno-economic evaluation: NPC



SUMMARY
CO_2-certificate

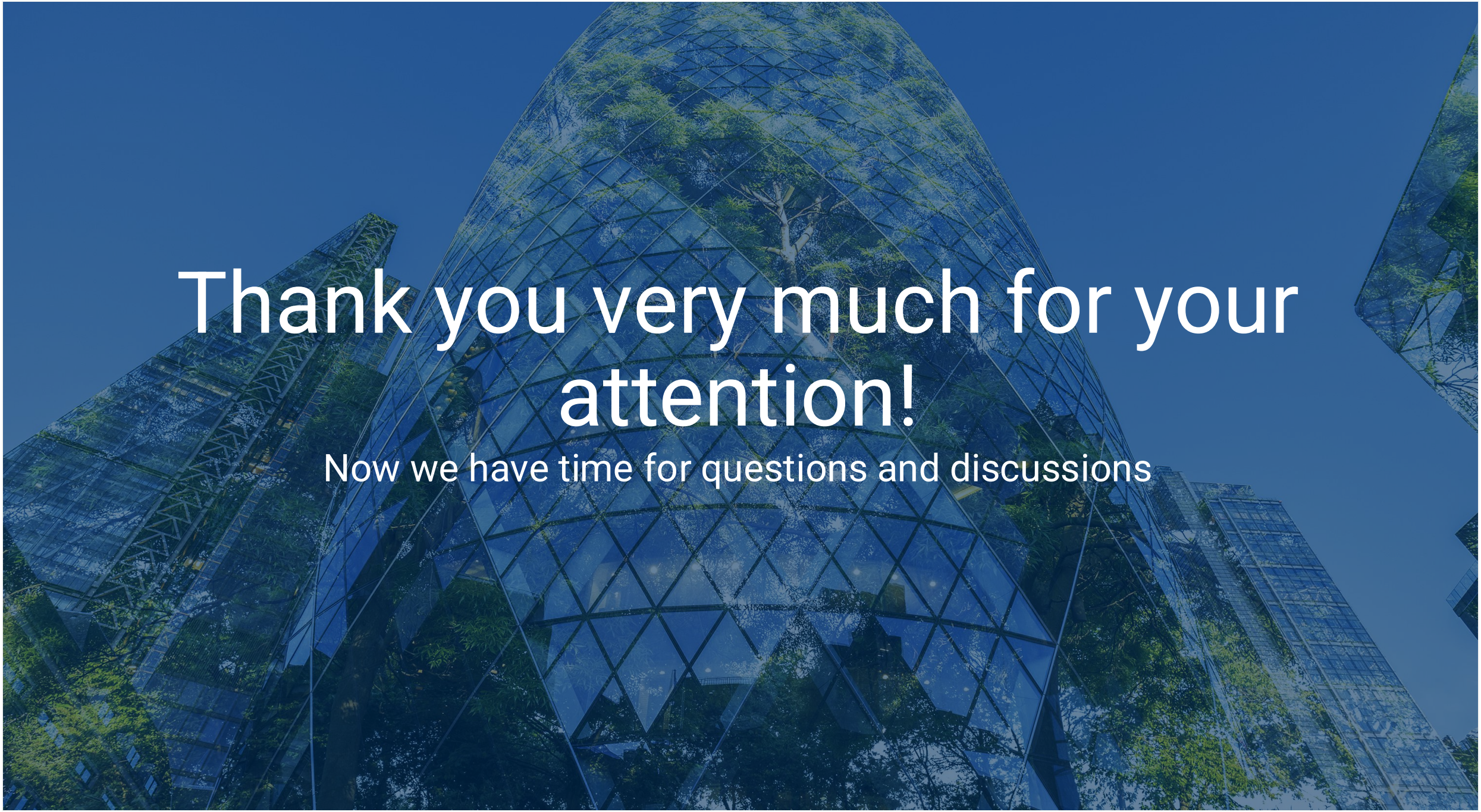
DACCS: ca. 1500€ / t CO_2

	NPC [€/MWh_{LHV}]
Ref. case: H_2	260
… + DACCS	438 ⇑⇑
a) H_2 + Methanol surplus	471
b) Surplus Methane: 30 kg/t_{glass}	448
c) Surplus Methanol: 60 kg/t_{glass}	454

PROJECT SUMMARY

We don‘t have much time until 2045!

- The future **WILL BE EXPENSIVE**: > 440 €/MWh_{LHV} if we avoid CCS
- 100% Cullet + H_2 is the easiest way to produce CO_2 neutral glass
- We have no experience in intensive gas cleaning
- CCS may be an interesting alternative



Thank you very much for your attention!

Now we have time for questions and discussions

FOLLOW-UP PROJECT

C4GLASS – Carbon cycles for glass production

This is what we want to do:

- Convert raw flue gas into fuel
  - About 1000 t/a CO_2
  - (ca. 200 Nm^3/h flue gas @30%$_{vol}$ CO_2)
- Test and evaluate the functionality of the cycle process
- Proof of concept for CO_2-neutral glass production

We need partners!

- Access to raw flue gas
- Space for container solutions
  - Flue gas purification
  - Electrolyzer module
  - Fuel synthesis
  - Gas storages
- Detail engineering, procurement & construction (EPC)
- Pilot plant operator (potentially by further external partners)
- Access to pilot plant surveillance

C4GLASS
Potential Project Adjustment

- Flue gas composition (e.g.: air-fuel, cullet%)
- SynFuel
  - Methane and methanol: techno-economic assessment available
  - Syngas, other hydrocarbons, …
- Pilot plant layout
  - Scale down
  - Adjustment to on-site available resources